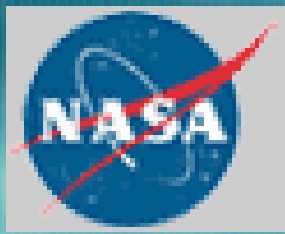
# Disaster Monitoring Constellation Experiment


NATIONAL AERONAUTICS
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# SSTL, NASA & Cisco

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## IP in Space

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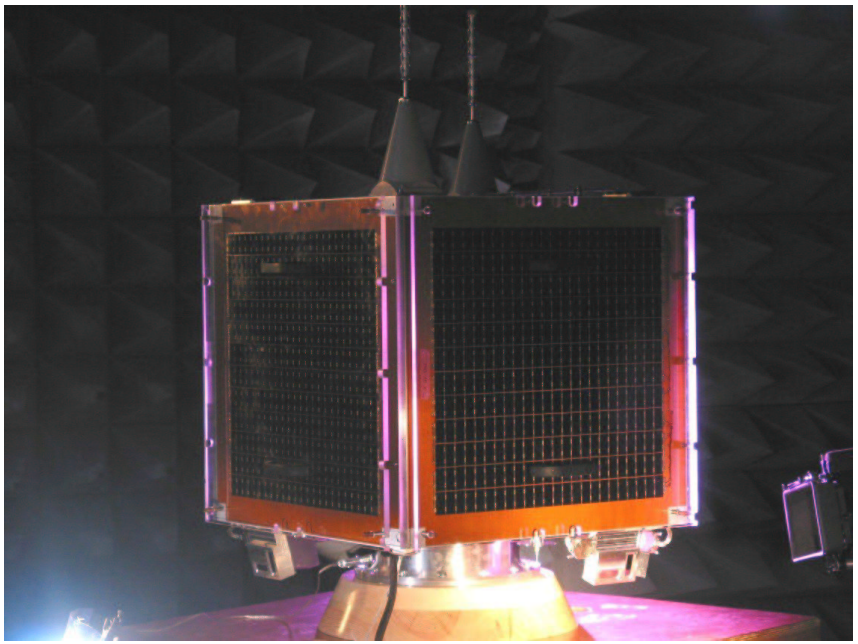
# UK-DMC LEO Bird

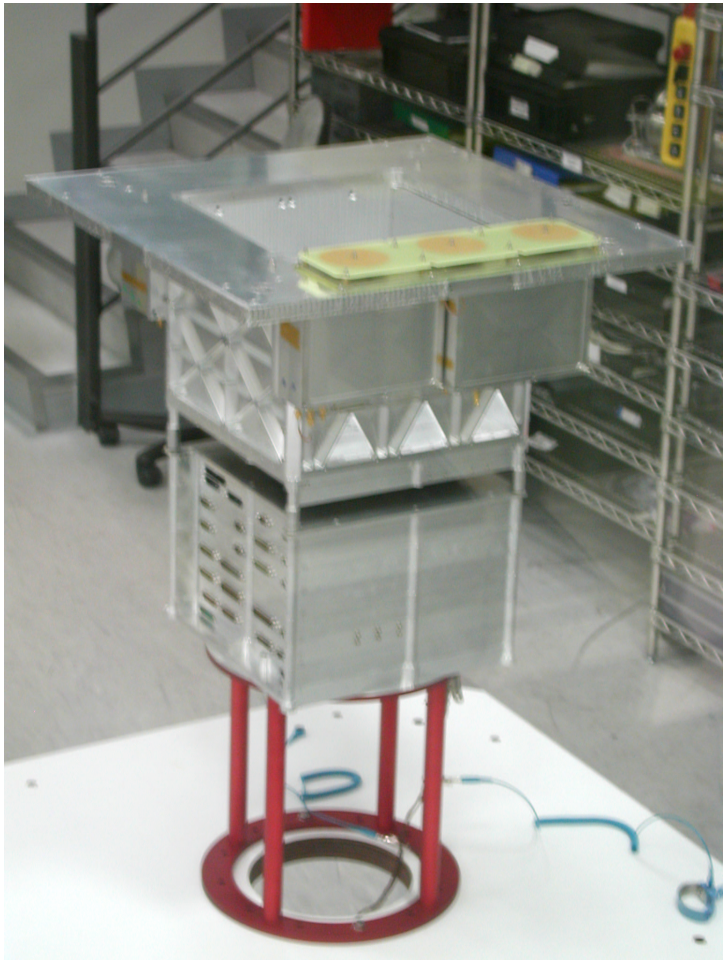


- 30 Meter IR Mission
  - Forrest Fires
  - Volcanic Activity
- 6 S/C Constellation
- Short Turn Around
- Integration Completed

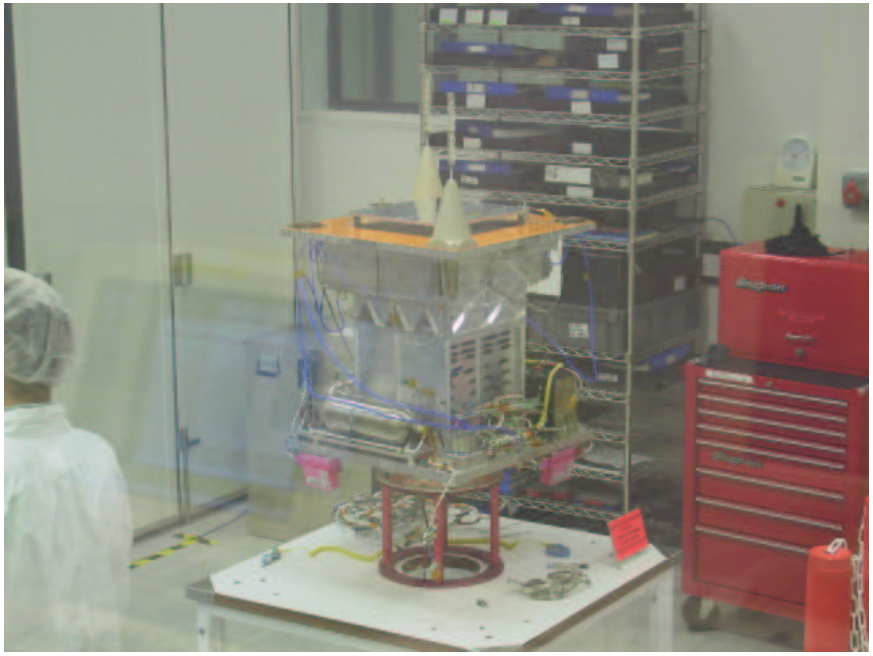


# Satellite Sub Assembly





UK- DMC Satellite



Nigerian DMC Satellite

# Router Payload



- Modified Cisco 3251 (MAR)
- Replaced all wet capacitors
- Removed all plastic connectors
- Tests include
  - 10G shock test
  - Thermal vacuum test (Space test)
    - Thermal dissipation
- Operational 4-6 sunlight passes/day

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# Cisco 3200 Series Mobile Access Router System View

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- **Mobile Access Router Card (MARC)**

  High performance processor, One 10/100 Ethernet, one console, one aux port, fixed memory

- **Mobile Interface Cards (MICs)**

  Serial MIC : 4 sync/async serial

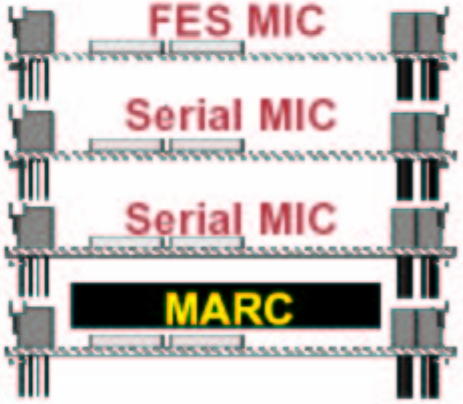
  FES MIC: 10/100 Ethernet, with 4 port switch

- **3200 Series Mobile Access Router configuration limits**

  Limit 3 MIC's per router, mix and match

  1 Mobile Access Card mandatory per router

  Limit 1 FESMIC per router




The stack shown above has 8 Serial interfaces, 1 FE port +4 FE Switch ports, 1 Console, 1 Aux

# Serial Mobile Interface Card (SMIC)



- 4 Port Serial interfaces
- All existing 12:1 signals supported
- Each interface supports up to 2Mbps
  - Asynch/Synch serial
- Typically used for a WAN interface to an existing wireless/satellite network
- Headers on board for external connection
  - No on-board connectors
  - See slide 19 for more details

# Fast Ethernet Switch MIC (FESMIC)



- 1 10/100 Ethernet with 4 port switch with VLAN
  - 802.1q and 802.1p supported
- Limit one FE MIC per mobile router router (3200 Series MAR)
- No in line power provided
- ISL not supported
- Headers on board for external connection
  - RJ45's are not located on board

# Mobile Access Router Card (MARC) Overview



- MPC8250, running at 200MHz CPU core, 133MHz CPM core and 66MHz Motorola 60x Bus
- 32-bit PCI bus version 2.1 running at 33MHz, connects to Cisco MICs
- 128Mbyte 64 bit, Unbuffered, Synchronous DRAM
- 32Mbyte 16 bit of Flash memory
- Single 10/100 Fast Ethernet, full-duplex 100 Base-T, with auto negotiation
- Single Console, with modem flow control
- Single Asynchronous, RS-232 serial, for GPS/AUX devices
- Integrated host-to-PCI bridge (PCI bus version 2.1)

# Cisco 3251 Mobile Access Router

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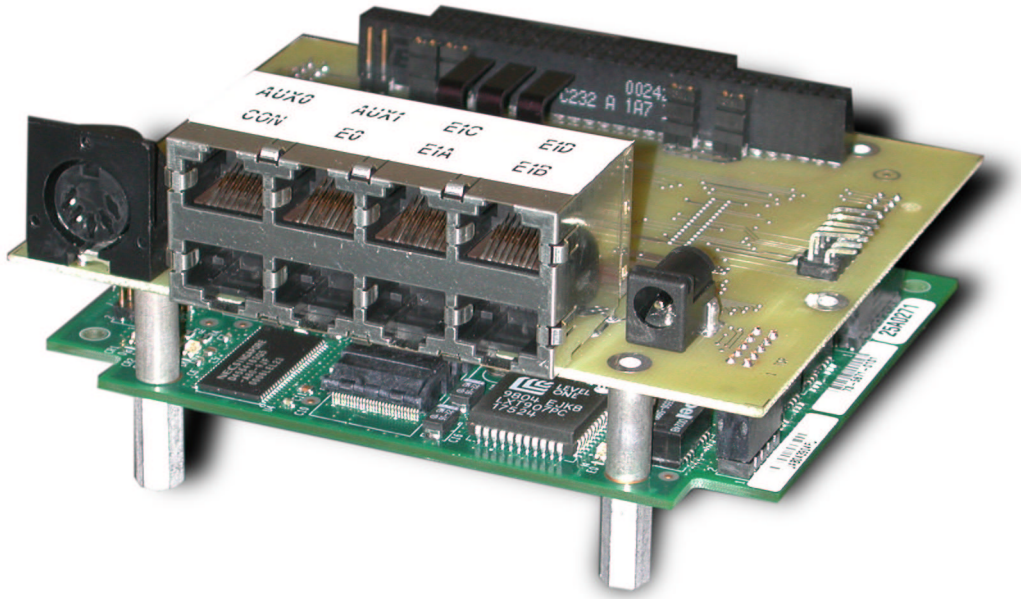
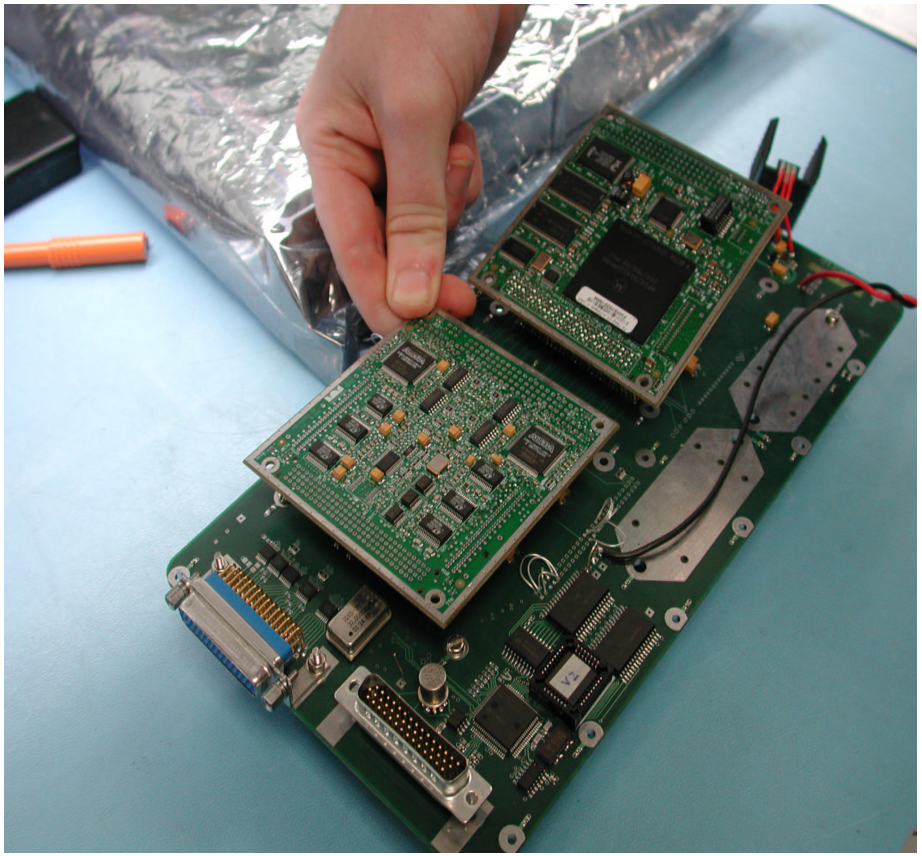


# Custom interface board



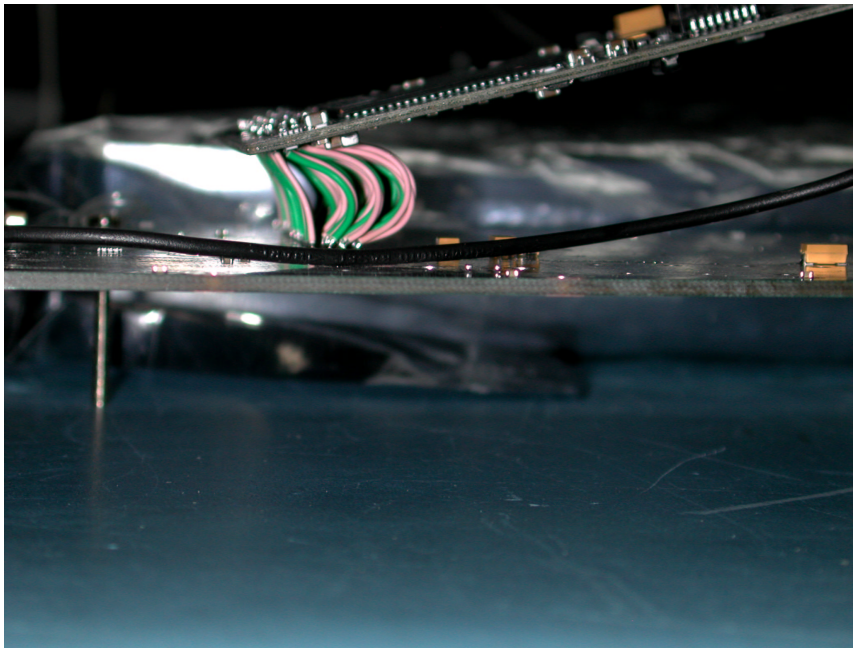
- Integrates MAR to CAN
- Provides Serial interface to payload
- Provides power
- Out of band connectivity



# Custom “Ribbon” cable



- Standard ribbon cable wouldn’t work
- Trick was to determine length



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# Completed Ribbon Cable

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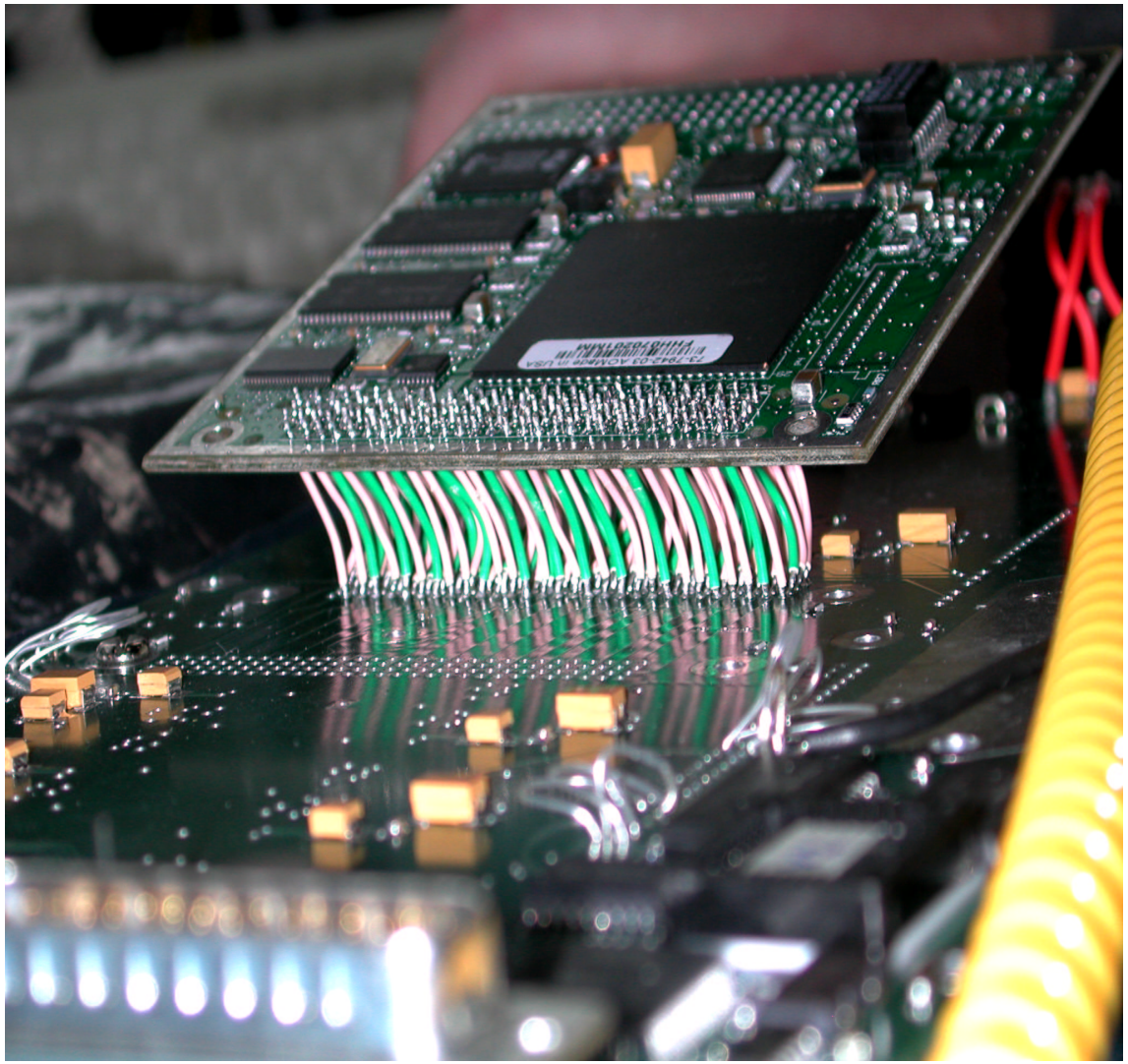

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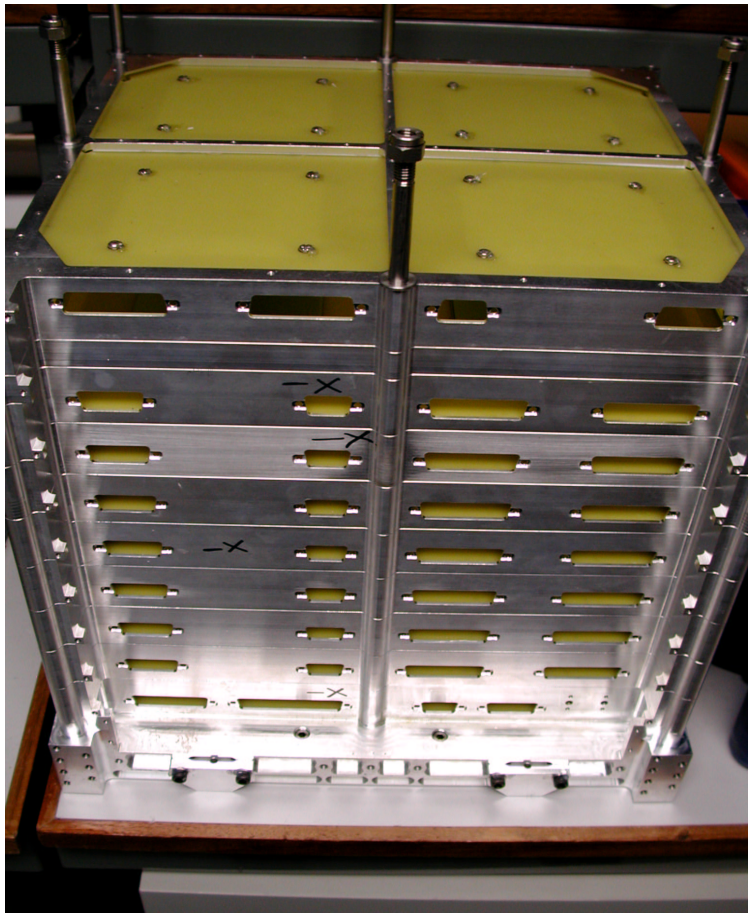
# Satellite Chassis



- **Each shelf provides different payload function**
  - **•Computing**
  - **•Navigation**
  - **•Monitoring**



# DMC Constellation Phase 1 Launch Details



- Launch July 28, 2003
- Russian Supplied Cosmos 3-M Rocket
- Launch Site PLESETSK Space Centre
- NASA Funded Ground Station for Cisco/NASA Testing and Operations

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# DMC Satellite Operational Objectives



- Survivability of COTS Products in Space
- Operational Data Path for Both Mission Data and System House keeping
- IP  Routing & Performance Characteristics
- Mobile IP Testing
- Possible Software Upgrades ?

# Spacecraft Network Attributes to be Tested

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- Failure Management
  - Detection
  - Isolation
  - Recovery
  - Notification
- Configuration Management
  - Network
  - User / asset profiles
  - Hardware inventory
  - Software versions / updates
  - Routing tables
- Performance Management
  - Data collection
  - Resource planning
  - Service monitoring
- Resource Management
  - Link allocation
  - Bandwidth allocation
  - Dynamic scheduling
  - User prioritization
  - QOS requirements (traffic shaping, etc…)
- Security Management
  - User authentication
  - Data access
  - Tasking control
  - Payload control
  - Platform control
  - Key distribution
  - Data/command interception
  - Data/command interruption
  - Data/command replay attack
  - Masquerade attack
  - Inference (unencrypted IP header issue)
  - Mobile IP routing
- Contention Management
  - Multiple PI's on same instrument
  - Multiple instruments on same spacecraft
  - Multiple spacecraft in view of single GS
  - Multiple GS in view of single spacecraft
- Accounting Management
  - Billing / fairness policies
  - Mobile IP: multiple spacecraft host registration

# What Do We Hope to Demonstrate?

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- **The viability of taking a purely COTS network product and using it in space**
  - **Space modifications**
  - **Qualification**
- **Quantified performance of the device under actual space conditions (vacuum, radiation, etc...)**
  - **Power consumption** **Voltage** **Temperature**
- **Detection of and recovery from unexpected device operations (reboot on orbit)**
- **Update / revision of device configuration on orbit**
- **Network operations on orbit**

| | |
|---|---|
| **Mobile IP** | **NTP** |
| **Mobile Router** | **Real time TCP/IP session** |
| **RIP** | **FTP** |
| **ARP/RARP** | **SNMP** |
| **MDP** | **HTTP** |
| **UDP** | **PHP** |
| **SSH** | **SCP** |

- **Pre-flight modeling / performance comparison**
  - **STK** **OPNET, Berkley NS**

# What Do We Hope to Demonstrate?

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- **Additional mission operations techniques**
  - Secure field data dissemination (multiple hops)
  - Use of commercial assets
  - Predictive routing / mobile connection (on the fly)
  - Access on demand, NAPSTER-like data interface
  - Data mining
  - Operations from remote locations
- **Protocol evaluation**
  - Compression technique performance characterization
  - Performance characterization with sub-optimal links
  - Performance characterization with overloaded on-board network
- **Applied spacecraft network security research in the following areas:**
  - User authentication techniques
  - Data encryption, Unauthorized user detection and mitigation
  - Key management, Performance characterization of security implementations
  - Mobile IP / Router security schemes
  - Virtual private network techniques
  - Command / data interception, interruption, modification, or replay detection and mitigation
  - Packet header inference mitigation techniques
  - System integrity tests (penetration testing)

# Protocol Comparison Criteria

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- Latency tolerance
- Data time correlation and synchronization support
- Link error tolerance
- Throughput versus delay / bit error rate
- Packet overhead (header versus payload)
- Bandwidth efficiency
- Interoperability with existing terrestrial systems (not simple IP wrapping)
- Flexibility to accommodate future protocol changes
- Time line savings
- QOS support and functionality
- Service type support
- Risk mitigation functionality
- Disaster recovery functionality
- End user application awareness & support capability
- Variable, on the fly, packet size support
- Multicast support
- Mobility support (overhead, dynamic registration, …)
- Life cycle cost savings
- Multiple level access control
- Multi-domain, dynamic network security and encryption

# Virtual Mission Operations
## Survivable Satellite Operations

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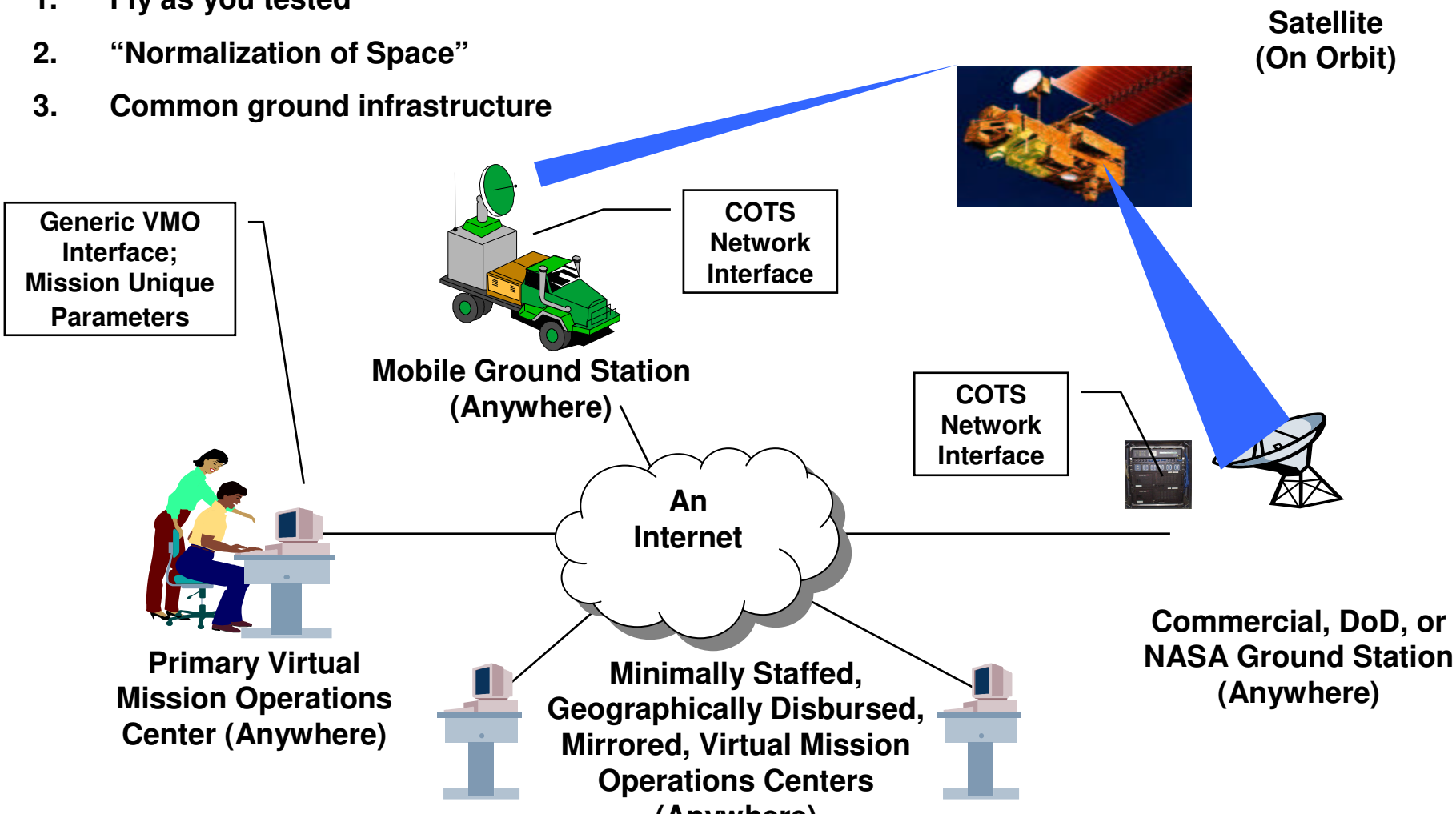
**Goals:**

1. Fly as you tested
2. "Normalization of Space"
3. Common ground infrastructure



# Other Mobile IP activities

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- MIL-STD-1553 to IP interface with Cisco 3251 and web GUI
- Rate Based Satellite Control Protocol in Cisco IOS
- Demo with USCG and NASA GRC for Cisco 3251/Globalstar testing
- Use of the NASA GRC van for Mobile IP demo
- NASA GRC NRA for IP Based C&DH system using Cisco 3251
- SDO Gig E NIC Card for S/C proposal?

# Summary

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- A transformation in satellite communication services moving toward internet-like connectivity is underway
- Use of Internet Protocol and standards in space offer significant advantages:
  - Reduced cost and schedule to develop future spacecraft.
  - Seamless interoperability of future satellites with existing terrestrial networks.
  - Survivable, remote, “virtual” mission operations / satellite command and control
- Development of RAD-hard network components, qualification, and flight testing are all critical to the deployment of IP-compliant systems in space.
- The use of Internet Protocols in space introduces new challenges, particularly in the area of network security.
- The commercial networking industry offers opportunity to leverage existing terrestrial standards as baseline for future space-based internetworking.

# Contact information

Cisco.com

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